Jan. 4, 1938. H. B. BREEDLOVE 2,104,635

MEANS AND METHOD FOR SUPPRESSING INTERFERENCE IN RADIO RECEPTION

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FIG. 1.

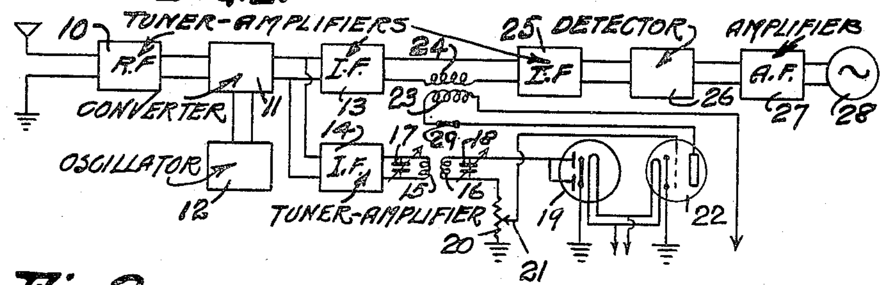
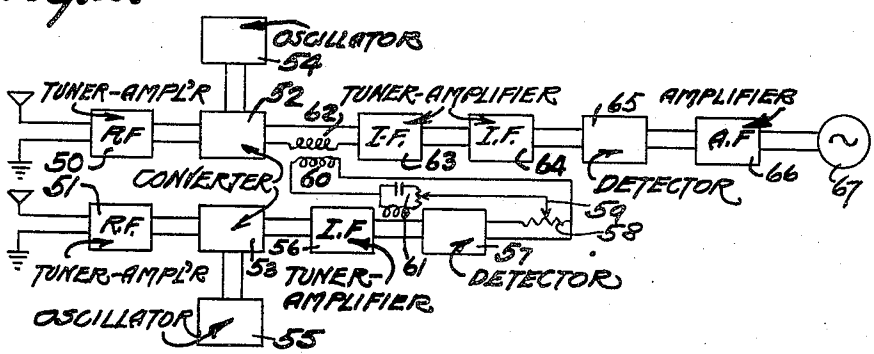


FIG. 2.



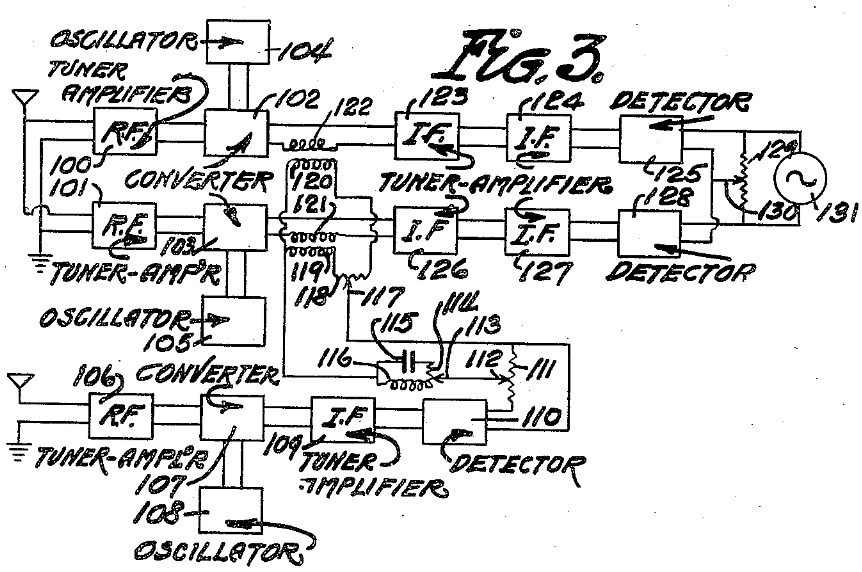


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FIG. 4.

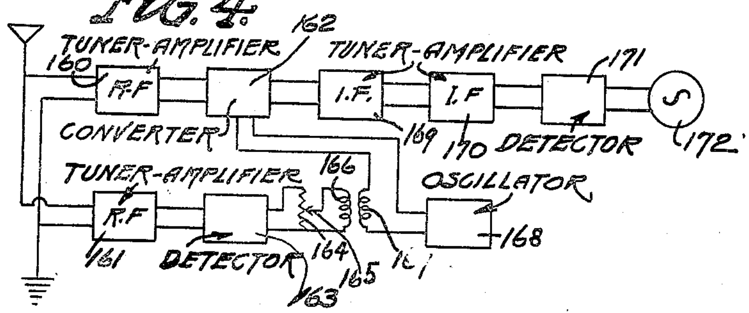

FIG. 5.

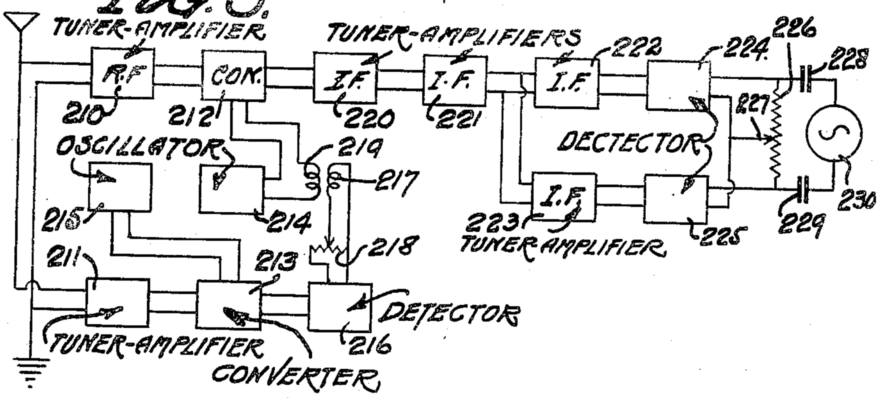

FIG. 6.

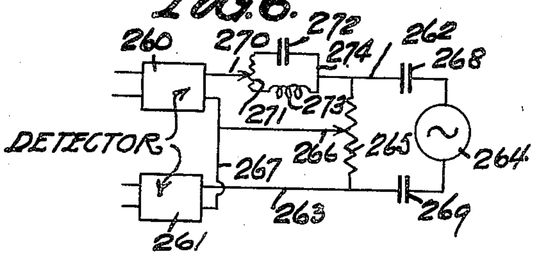

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FIG. 7.

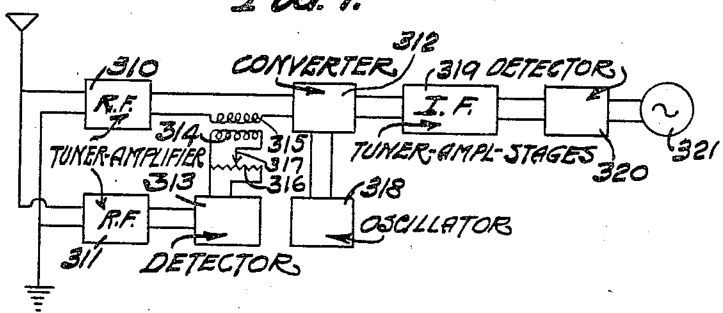

FIG. 8.

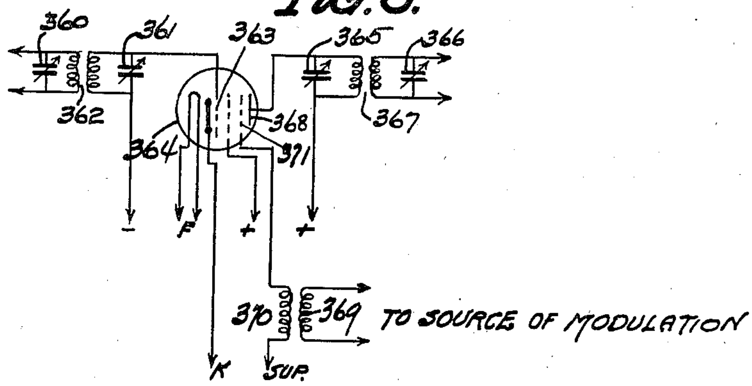

FIG. 9.

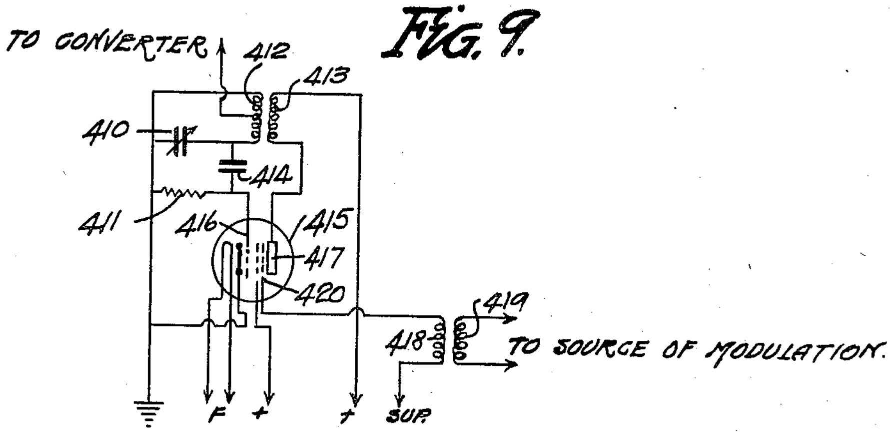

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FIG. 10.

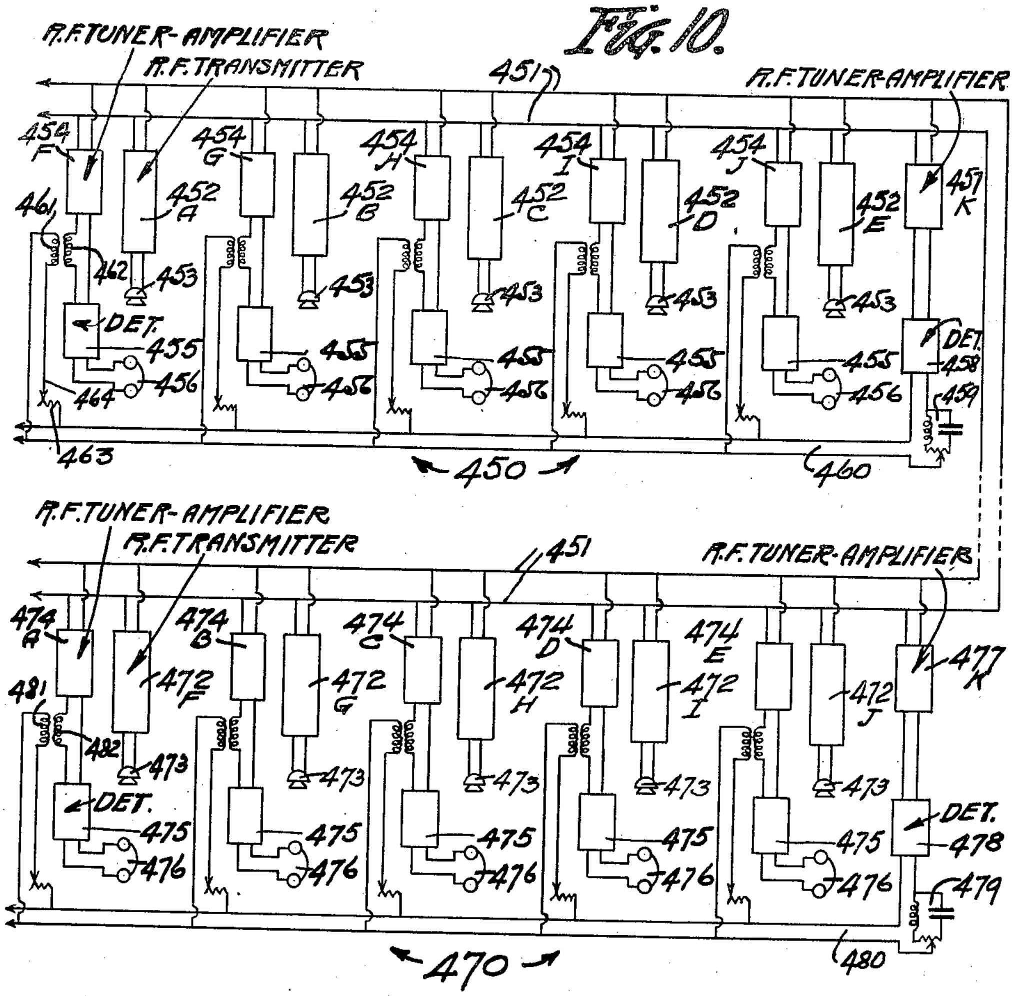

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FIG. 11.

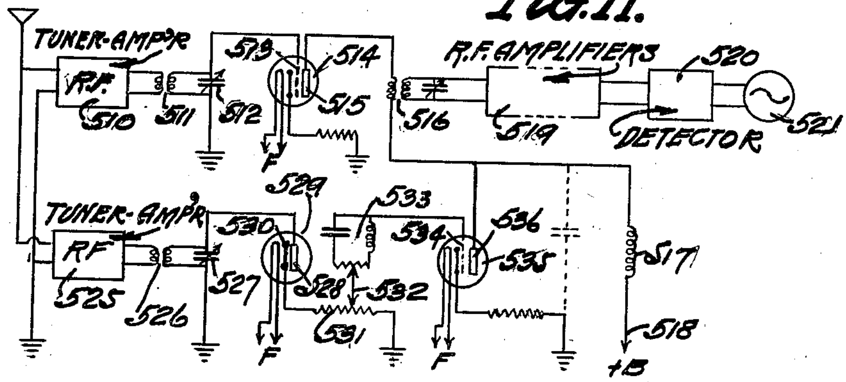


FIG. 12.

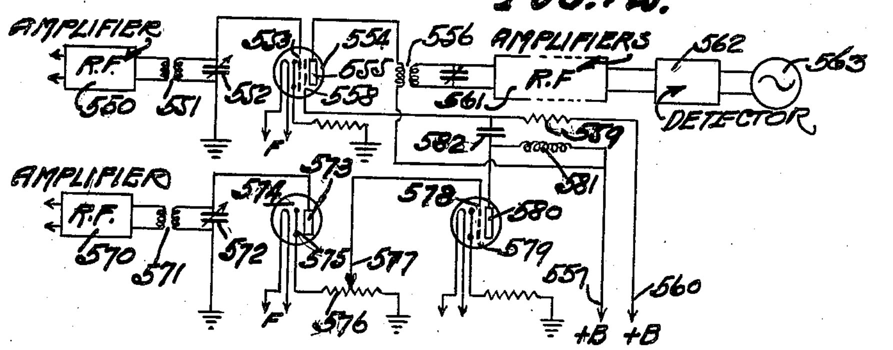
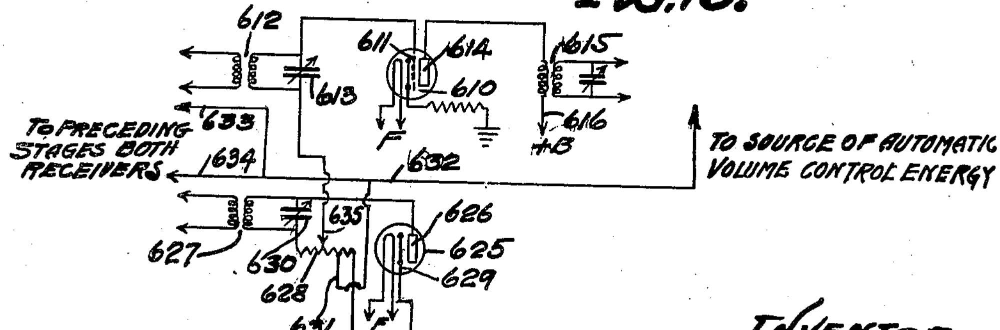


FIG. 13.



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Patented Jan. 4, 1938

2,104,635

UNITED STATES PATENT OFFICE

2,104,635

MEANS AND METHOD FOR SUPPRESSING INTERFERENCE IN RADIO RECEPTION

Harry B. Breedlove, Memphis, Tenn.

Application January 16, 1936, Serial No. 59,342

23 Claims. (Cl. 250—6)

This invention relates to means and methods for removing or suppressing interference, including static, which interferes with the reception of signalling currents transmitted at radio frequencies either over wire, air, or other non-metallic circuits. It relates to the suppression or removal of such interference in complete wire circuits, wire and non-metallic circuits or wireless broadcast-receiving circuits.

It primarily relates to means and methods for utilizing two or more bands of frequencies, which bands preferably are adjacent bands, but which in many, or probably most, cases must be separated by intervening frequency bands, for receiving signals at radio frequencies, the interference on one band being used to demodulate and/or cancel out interference on the other or others thereof. It will be understood that the word "demodulate" as here and hereinafter used, is intended to mean the removal of intensity variations or variations in amplitude by modulating or otherwise opposing them with like, but out of phase intensity variations.

It further relates to means and methods for using two or more bands of frequencies for receiving signals at radio frequencies, one of such bands being un-used, at least locally, so far as signal carrying waves are concerned, and being used solely to receive interference, which interference is used to demodulate the interference on the other band or bands.

In general it is directed in receiving signalling currents at radio frequency, toward the utilization of interference which may enter the receiver in one band to demodulate the interference entering in another band or bands.

In usual transmission at radio frequency, a carrier wave of desired frequency, signal modulated in intensity, is transmitted from a sending antenna and received over the antenna of a suitable receiving apparatus, such carrier waves when received being often accompanied by static or other interference which hinders or even prevents reception.

In the instant invention the interference on a signal vacant channel is detected to substantially remove its carrier wave frequency, and the intensity output, substantially free from carrier wave frequency is used to demodulate or otherwise oppose and cancel the interference intensities accompanying a carrier wave of different frequency which is signal modulated in intensity; the said intensity output of the first channel mentioned being imposed on some stage of the other channel prior to final detection.

Or a first carrier wave signal modulated inversely in intensity with respect to a second carrier wave modulated in intensity by the same signal, is reinverted after it is received, and detected to substantially remove the carrier wave frequency, and the intensity output of said first wave is combined with such second wave prior to final detection of the latter, in such manner that the signal intensities of the first wave supplement those of the other, whereas interference intensities entering the receiver with said first wave are inverted by the said reinversion of the first wave and when the waves are combined demodulates the interference of the second wave.

Or the interference intensities of a signal vacant channel, after being detected and divorced from their carrier wave, are used to demodulate the interference of two, or even a greater plurality of, signal modulated carrier waves each of a different frequency and of a frequency different from that of the signal-vacant channel;

In a modification of the device, two carrier waves of different frequencies, jointly modulated out of phase in intensity by a common signal, are received and their interferences severally demodulated by the interference intensities of a signal-vacant channel at a third frequency after said latter intensities have been freed from their carrier wave frequency and after such demodulation, the two signal bearing carrier waves are reinverted and after final detection combined to oppose and cancel out remaining interference intensities.

It will be understood that while it is preferable to use a channel entirely signal-vacant, that a locally signal-vacant channel may be used.

Interference, while not predeterminable as to phase, intensity, or variation in intensity, being inherently identical in phase and these characteristics in adjoining radio frequency bands, and substantially identical in bands even though they are separated by a limited number of intervening bands, the primary object of this invention is to use the interference intensities on one frequency band for cancelling out the like phase and characteristic intensities on another band or bands.

Further objects of the present invention are, in receiving energy at radio frequencies;

To provide means and methods for utilizing the interference intensities in a signal vacant band of radio frequencies for demodulating or otherwise removing, the interference intensities of a signal modulated carrier wave of different radio frequency.

To provide means and methods for utilizing the interference intensities in one band of radio frequencies for demodulating relatively inverted interference intensities in a second band of radio frequencies in which the signal intensities are in phase.

To provide means and methods for receiving signalling energy at radio frequencies, either over wire, the air, or other circuits, which means employs the interference intensities received in an energy vacant radio frequency channel, after they have been substantially freed from their carrier wave frequencies, to demodulate the interference received with a plurality of energy modulated carrier waves at different and differing radio frequencies.

To provide means and methods for utilizing the interference intensities in one signal vacant band, at radio frequency, for demodulating the interference in two bands of different and differing radio frequencies which in sending have been modulated out of phase in intensities by the same signal, and for combining the interference-demodulated intensities of such two bands in re-inverted intensity phase, whereby to cancel out the remaining interference intensities.

To provide means and methods for receiving signalling energy at radio frequencies, either over wire, the air, or other circuits, which means employs two or more frequency bands, at least one of which bands carries a wave, signal modulated in intensity, and which means utilizes the interference intensities on another band of radio frequencies, after they have been substantially freed from their carrier wave frequencies, for demodulating the interference in the signal carrying band.

The means by which these and other objects are accomplished, and the manner of their accomplishment will readily be understood from the following specification on reference to the accompanying drawings, which show diagrammatic views of the general arrangement of receivers embodying my invention, and some of the various hookups that are effective therewith, all embodying the use of circuits for at least two frequency bands, and in which,

Fig. 1 shows the employment of two super heterodyne circuits using a single radio frequency tuner amplifier.

Fig. 2 shows the employment of two super heterodyne circuits using independent radio frequency tuner amplifiers.

Fig. 3 shows the employment of two super heterodyne circuits modulated by a third super heterodyne circuit.

Fig. 4 shows a modified form of receiver employing a tuner radio frequency circuit and a super heterodyne circuit.

Fig. 5 shows a modified receiver employing two super heterodyne circuits.

Fig. 6 is a detail applicable to Figs. 3 and 5, showing a specific hookup between two second detectors and the signal output device.

Fig. 7 shows a modified form of receiver employing a tuned radio frequency circuit and a super heterodyne circuit.

Fig. 8 shows a specific hookup from one circuit accomplished through a grid of a tune, of a second circuit.

Fig. 9 shows a specific hookup particularly applicable to Figs. 4 and 5 showing one circuit coupled to a second circuit through a grid of such second circuit.

Fig. 10 shows two interconnected circuits particularly adapted for telephone service.

Fig. 11 shows two circuits and a specific hookup from one circuit to a plate circuit of the other circuit.

Fig. 12 shows two circuits and a specific hookup from one circuit to a screen grid of the other circuit.

Fig. 13 shows a fragmentary portion of two circuits and a hookup between one circuit and the control grid of the other circuit.

Referring now to the drawings in which the various parts are indicated by numerals, in Fig. 1; **10** is a broadly tuned radio frequency tuner amplifier, adapted to tune and separate out a band of frequencies wide enough to include two, or even several usual adjacent bands of frequencies. **11** is a converter or first detector and **12** is a local oscillator, the energy from which is impressed on the converter in usual manner; the converted output being delivered in parallel to tuned intermediate frequency amplifiers **13**, **14**, each adapted to select and tune from the broad band a single band of intermediate frequencies, thus establishing a first and a second frequency channel. **15** and **16** are respectively the primary and secondary of a coupling and **17**, **18** variable condensers. **19** is a diode of the heater type. **20** is a grounded resistance which is connected by a variably tapped lead **21** to the grid of a triode **22**. The coil **16**, condenser **18**, diode **19** and resistor **20** form a detector circuit the output of which is amplified by the triode **22**. The plate circuit of the triode **22** is connected to the primary **23** of a modulation transformer in such manner that the audio frequency in the said primary will oppose like intermediate frequency intensity variations in the secondary **24** of the coil, this secondary being in the output circuit from the amplifier **13** to an intermediate frequency amplifier **25**, the output of which amplifier is impressed on a detector **26**. **27** is an audio frequency amplifier and **28** a signal output device.

29 is a switch in a circuit of the second frequency channel, which switch when opened allows the first channel to be used in usual manner.

In Fig. 2, **50**, **51** are radio frequency amplifier tuners, each adapted to receive and separate out a desired normal band of frequencies. **52**, **53** are converters and **54**, **55** local oscillators. **56** is an intermediate frequency amplifier and **57** a detector. The output from the detector **57** is delivered through a circuit having a resistance **58** and variable tap **59**, to the primary **60** of a modulation transformer, through a variable phase change device **61**, the secondary **62** of the transformer being in the output circuit from the converter **52** to the first intermediate frequency amplifier **63**. **64** is a second intermediate frequency amplifier, **65** a detector, **66** an audio frequency amplifier and **67** a signal output device. As in the preceding form of the device the detector **57** is connected to the primary of the transformer **60** in such manner that the audio frequency variations oppose like intensity variations in the secondary **62**.

In Fig. 3, **100**, **101** are radio frequency tuner amplifiers, each adapted to receive and separate out a normal band of radio frequencies, **102**, **103** are converters which respectively receive these bands of frequencies and **104**, **105** their respective local oscillators. **106** is a third radio frequency tuner amplifier adapted to receive and separate out a single band of frequencies. **107** is a converter or first detector and **108** a local oscillator. **109** is an intermediate frequency amplifier for the output of the converter **107**, and **110** a detector for the output of the amplifier 109. The output of the detector 110 passes through a circuit, which includes resistance 111 and a variable tap 112 and is connected through an adjustable tap 113, to a phase-adjusting device comprising resistance 114, one end of which is connected to a condenser 115 and the opposite end to a coil 116. The circuit from the phase-adjuster is completed preferably parallel through the respective primaries 119 and 120 of two modulation transformers to opposite ends of a resistance unit 118. The adjustable tap 117 of this unit being connected back to the detector. The output of the detectors 110 is connected to the primaries 119, 120 in such manner that the current variations from this detector oppose like intensity variations in the secondaries 122 and 123. The secondary 121 of the first of these transformers is connected in the output circuit from the converter 103, and the secondary 122 of the other transformer in the output circuit of the converter 102. The output circuit from the converter 102 leads through the secondary 122 through amplifiers 123, 124 to a detector 125, and the output of the converter 103 through the secondary 121 and through intermediate frequency tuner amplifiers 126, 127 to a detector 128. The circuit from the detector 125 is inversely connected in series with the detector 128. 129 is a resistor bridging the circuit and 130 a variable tap leading back to both detectors. 131 is a signal output device.

In Fig. 4, 160—161 are radio frequency tuner amplifiers each adapted to receive and separate out a single band of frequencies. 162 is a converter or first detector which receives the output of the tuner amplifier 160, and 163 a detector which receives the output of the tuner amplifier 161. The output circuit of the detector 163 is bridged by a variable resistor 164, which is connected by a variable tap 165 to the primary 166 of a modulation transformer having a secondary 167. 168 is a local oscillator the energy from which is impressed on the converter 162, the secondary 167 being in the connecting circuit. The primary 166 and secondary 167 of the transformer are relatively so connected in their respective circuits that the energy from the detector 163 modulates the energy from the local oscillator 168 in opposing phase relation to the interference received in the converter 162. 169, 170 are intermediate frequency amplifier tuners through which the output from the converter 162 passes to a detector 171. 172 is a signal output device.

In Fig. 5, 210 is a radio frequency tuner amplifier adapted to tune and separate out a band of frequencies wide enough to include several usual bands of frequencies. 211 is a radio frequency amplifier tuner adapted to receive and separate out a normal band of frequencies. 212, 213 are respectively converters or first detectors respectively receiving the output of the tuner amplifiers 210 and 211. 214 and 215 are tuned local oscillators whose outputs are respectively impressed on the converters 212 and 213. 216 is a detector receiving the output from the converter 213, the output of the detector being in circuit with the primary 217 of a modulation transformer. 218 is a variable tapped resistor in the circuit. 219 is the secondary of the modulation transformer, this secondary being in the output circuit from the oscillator 214 to the converter 212. The primary 217 and the secondary 219 of the transformer are relatively so connected in their respective circuits that the energy from the detector 216 modulates the energy from the local oscillator 214 in opposing phase relation to the interference received in the converter 212. 220, 221 are intermediate tuner amplifiers in series which receive the output of the converter 212. The output of the amplifier 221 passes in parallel to intermediate frequency amplifiers 222, 223, which tuner amplifiers each separate out from the broad band of frequencies delivered by the amplifier 221, a normal band of frequencies.

The outputs of the amplifiers 222—223 pass respectively to detectors 224—225, and the detected outputs are combined in opposed phase relation. 226 is a resistor bridging the circuit employed and 227 a variable tap leading back to the other leg of the circuit. 228 and 229 are respectively condensers and 230 a signal output device.

In Fig. 6; 260—261 are detectors which are inversely connected together by legs 262—263 through a signal output device 264. 265 is a resistor bridging these legs of the circuit and 267 a variable tap leading back to a second leg of the circuit connecting the detector. 268, 269 are condensers in the legs 262, 263. The leg 262 of the circuit from the detector 260 includes a tap 270 adjustably connected to a resistor 271 of a phase adjusting circuit, the opposite ends of the resistor being respectively connected through a condenser 272, and a coil 273, and a joint lead 274 tieing the opposite ends of the condenser and coil legs together. Similar phase change devices 61 and 114 are shown in Figs. 2 and 3, and may also be introduced in any of the other circuits shown.

In Fig. 7; 310, 311 are radio frequency tuner amplifiers each adapted to tune in a normal band of radio frequencies. 312 is a converter or first detector receiving the output of the amplifier 310, and 313 a detector for the amplifier 311. The output of the detector 313 is delivered to the primary 314 of a modulation transformer the secondary 315 of the transformer being in one leg of the output circuit from the amplifier 310 to the converter 312. The output circuit of the detector is bridged by a resistor 316 having a variable tap 317 adjustably controlling the output to the primary 314. 318 is a tuned local oscillator connected to the converter 312. 319 are tuned intermediate frequency amplifier stages; 320 a detector and 321 signal output device.

In Fig. 8; 360, 361 are variable condensers and 362 an intermediate frequency transformer, which are connected to the control grid 363 of a triple grid electron discharge device 364. 365, 366 are variable condensers and 367 an intermediate frequency transformer connected to the plate circuit 368 of the tube 364. 369 and 370 are respectively the primary and secondary of a modulation transformer, the primary 369 of this transformer being coupled to a source of modulation such as the detector 57, Fig. 2, or 111, Fig. 3. The secondary 370 of the transformer is connected to the suppressor grid 371 of the tube 364 and to a desired source of suppressor grid energy. This connection through the transformer 369, 370 is such that the energy from the source of modulation is at 180 degrees to the like intensities impressed through the circuit connection to the control grid 363.

In Fig. 9 a variable condenser 410, a resistance 411, a transformer secondary 412 and primary 413, a condenser 414, and a triple grid tube 415, with their interconnecting circuits to the control grid 416 and the plate 417 constitute a tuned oscillator. 418 is the secondary of a modulation transformer and 419 the primary, one end of the secondary 418 of the transformer being connected to the suppressor grid 420 of the tube 415, and the opposite end to a desired source of suppressor grid energy. The primary 419 of this modulation transformer is coupled to a source of modulation such as detector 163 of Fig. 4, or the detector 216 of Fig. 5.

In Fig. 10; 450, 470 generally designate two telephone stations connected by a two wire, or metallic circuit, 451. In each station are the usual plurality of signal transmitting and a corresponding number of signal receiving devices, all at radio frequency, connected in parallel to these wire circuits, and in each a similar receiving device here used as a signal-vacant device for demodulating all of the signal receiving devices of the station.

In station 450, 452, A, B, C, D and E diagrammatically indicate the usual radio frequency transmitters and 453 their microphones, five of each being shown. 454 F, G, H, I and J are radio frequency tuner-amplifier receivers, the outputs of which amplifiers are severally passed to related detectors 455, and thence to their receiving sets 456. 457 is a similar radio frequency tuner-amplifier and 458 the detector therefor. The output of the detector 458 is passed through a phase change device 459 and a joint circuit 460, in parallel to the primaries 461 of modulation transformers, the secondaries 462 of these transformers being severally in the output circuit from the tuner-amplifiers 454 F, G, H, I, J to their respective detectors 455. The circuit through each primary 461 is completed through a resistance 463 and adjustable tap 464. In station 470 there is an identical set-up; 472 F, G, H, I and J designating the corresponding transmitters, 474 A, B, C, D and E the radio frequency tuner amplifiers; 475 the detectors, and 476 the receiving sets; 477 the modulating tuner-amplifier and 478 the detector; these, the remaining apparatus and hookups being identical in both stations.

In Fig. 11, 510 is a radio frequency tuner amplifier coupled in usual manner through a transformer 511 and a circuit bridged by the variable condenser 512 to the control grid 513 of an electron discharge device 514. The circuit from plate 515 of this device leads through the primary of a transformer 516 and through a coil 517 and lead 518 to a source of energy not shown. 519 are usual radio frequency stages, 520 an usual final detector and 521 a signal indicating device, these comprising one receiver.

525 is a similar radio frequency tuner amplifier coupled in usual manner through a transformer 526 and circuit bridged by a variable condenser 527 to the plate circuit 528 of a diode detector 529. The cathode 530 of the diode is connected to ground through a resistance 531. 532 is a variable tap connected through a phase change device 533 to the control grid 534 of an amplifier tube 535. The plate circuit 536 of this tube is connected to the lead 518 from an energy source, and through primary of transformer 516 to plate 515 of the tube 514.

In Fig. 12, 550 is a radio frequency tuner amplifier, coupled in usual manner through a transformer 551 and circuit bridged by a variable condenser 552 to the control grid 553 of an electron discharge device 554. Plate 555 of this device is connected through the primary of a transformer 556 and a lead 557 to a source of energy not shown. The screen grid 558 of the electron discharge device 554 is connected through a resistor 559 in a lead 560 to a source of energy not shown. 561 are usual radio frequency stages, coupled in usual manner, 562 is a final detector and 563 a signal indicating device.

570 is a radio frequency tuner coupled in usual manner through a transformer 571 and circuit bridged by a variable condenser 572 to the plate 573 of a diode detector 574 which has its cathode 575 grounded through a resistor 576. A variable tap 577 connects this resistor to the control grid 578 of an amplifier tube 579. The plate 580 of tube 579 is connected through a coil 581 in the lead 557 and is also connected through a condenser 582 to the screen grid 558 of tube 554.

In Fig. 13; 610 is a tube having its control grid 611 coupled in usual manner through a radio frequency transformer 612 to a preceding stage or stages of a receiver. 613 is a variable condenser. The plate 614 of tube 610 is connected through the primary of a transformer 615 and a lead 616 to a suitable source of energy not shown. The transformer 615 is connected to following stages. 625 is a diode detector of a second receiver, the diode having its plate 626 connected through the secondary of a transformer 627, and through a resistor 628 back to the cathode 629. Primary of transformer 627 is connected to a preceding stage or stages of the second receiver. 630 is a variable condenser. A lead 631 taken from a point on the resistor 628 is connected to a lead 632 from a source of automatic volume control. A variable tap 635 from the resistor 628 is connected to the secondary of the transformer 612 forming part of the secondary circuit. Automatic volume control lead 632 is connected through parallel leads 633, 634 to preceding stages of both receivers, and receivés energy from a source not shown, originating from the first receiver.

It will be understood that in any of the forms shown a disconnecting switch such as the switch 29 of Fig. 1 may be used.

It will also be understood that while superheterodyne circuits have largely been shown, radio frequency circuits may be used, except in the forms shown in Figs. 4 and 5.

In using the apparatus shown in Fig. 1 the tuner amplifier 10 is tuned to separate out a group of radio frequency bands one of which is the channel of a carrier wave bringing in the intensity modulations of a desired program or signal, and the other a channel which is either signal-vacant or brings in a different carrier wave modulated inversely or out of phase in intensities by the same program or signal. These two channels are adjacent, if conditions permit, but if not the group of bands includes intervening channels. All the channels so included in the group whether used or signal-vacant at times bring in interference or static intensities, which inherently are relatively in phase with each other. This group of bands so separated out is passed to the converter or first detector 11 and is there mixed in usual manner with the energy from a local tuned oscillator 12. The output of the converter 11 is led over two circuits to the intermediate frequency tuner-amplifiers 13 and 14, the amplifier 13 being tuned to separate out from the group of bands that band of frequencies which contain the desired program or signal intensities and such interference intensities as accompany it. The other tuner amplifier 14 is tuned to separate out from the group the other desired band of frequencies, which is either signal-vacant or inversely modulated in intensity, together with its accompanying interference intensities, these intensities being in phase with the interference intensities of the other band. Should no interference or static be present the switch 29 may be opened and the first mentioned channel used in usual manner entirely independent of the present invention.

The output of the tuner amplifier 14 passes through the coupling 15—16, to the plate circuit of the detector diode 19 and through the variable resistance 20—21 to the grid of the amplifier triode 22. The plate output of the triode 22 consisting of intensities substantially freed by the detector from the carrier wave frequency on which they entered, is impressed on the primary 23 of the modulation transformer which has its secondary 24 in the output circuit of the tuner amplifier 13. The interference intensities of the detected output thus impressed on the transformer demodulate and remove the interference intensities of the output from the tuner amplifier 13 with which they are out of phase and cancel them out, whereas the reinverted signal intensities being thus restored into phase, supplement the signal intensities of the tuner-amplifier 13 output. Should the ouput of the tuner-amplifier 14 contain no signal intensities, the signal-intensities of the tuner amplifier 13 pass unopposed, the interference intensities only acting. The output of the amplifier 13, thus freed from interference, is then in usual manner amplified in the intermediate frequency stage, detected, amplified in the audio frequency stage and delivered to the signal output device which may be the loud speaker of a radio receiver.

In using the form of device shown in Fig. 2, the tuner amplifiers 50, 51 are respectively tuned to separate out each a frequency band one of which is a channel bringing in the intensity modulations of a desired program or signal, and the other a channel which is either signal-vacant or brings in a different carrier wave modulated inversely, or out of phase, in intensities by the same program or signal. The outputs of these amplifiers, respectively pass to the converters 52—53 in which they are mixed respectively with the respective energies from local tuned oscillators 54 and 55. The output of the converter 53 passes through the intermediate frequency tuner amplifier 56, to the detector 57, the detected output thereof passing to the primary 60 of the modulation transformer. In passing to the primary 60, the phase of the output may be advanced or retarded by shifting the tap of the phase-adjusting device 61, the subsequent actions and results being as before outlined.

In using the apparatus shown in Fig. 3 the tuner amplifiers 100—101 are respectively tuned to separate out each a frequency band, one of which contains a carrier wave bringing in the intensity modulations of a desired program or signal and the other a second carrier wave at a different frequency which has in sending, been modulated inversely, or out of phase, in intensities by the same program or signal.

The outputs of these amplifiers respectively pass to the converters 102, 103 where they are mixed with the respective energies from the local tuned oscillators 104, 105 and respectively pass through output circuits which contain the secondaries 122—121 respectively to the intermediate frequency amplifiers 123—126. Concurrently, a third radio frequency band which is signal-vacant is tuned and separated out by the tuner amplifier 106. The interference output if any from the amplifier 106 passes to the converter 107 where it is mixed with the energy from the local oscillator 108 and passes through the tuner amplifier 109 to the detector 110. From the detector 110 the output passes through the circuits to the primaries 119 and 120 the output delivered to the two primaries being relatively adjusted by shifting the variable tap 117 with reference to the resistance 118. The phase of the interference intensities if any, of the output from the detector 110 are advanced or retarded by shifting the variable tap 113 upward or downward with relation to the resistance 114 as the case may be, in order that the said interference intensities will be 180 degrees out of phase in the primaries 119—120 with the interference intensities in the secondaries 121, 122 respectively and will thereby demodulate the interference intensities in such secondaries. The interference demodulated output of the amplifier 123 passes through the amplifier 124 and the detector 125, and the interference demodulated output of the amplifier 126 through the amplifier 127 and the detector 128 and the two outputs are inversely combined in the signal output device 131 thus removing any remaining interference in the two outputs and causing the signal intensities of the two outputs to supplement one the other.

In using the form of device shown in Fig. 4 the tuner amplifiers 160—161 are respectively tuned to separate out each a frequency band, the first of which is a channel bringing in the intensity modulations of a desired program or signal and the second a channel which is either signal vacant or brings in a different carrier wave modulated inversely, or out of phase, in intensities by the same program or signal, the output of the amplifier 160 being delivered to a converter or first detector 162. The output of the amplifier 161 is delivered to a detector 163 and passes therefrom to the primary 166 of the modulation transformer, and is there used to modulate the energy from the oscillator 168 as it passes through the secondary 167 of the transformer, thus delivering from the local oscillator to the converter energy which is modulated in interference intensities out of phase with the first channel interference intensities in the converter and provided the second carrier wave was signal modulated, also delivering signal intensities in phase with those entering the converter in the first channel. This modulated energy from the oscillator is mixed in usual manner in the converter with the input from the radio frequency amplifier 160, changing the radio frequency input to intermediate frequency demodulating the out of phase interference input, and either supplementing the in phase signal intensity input or having no action thereon depending on whether a signal carrying or vacant second channel was employed.

In using the apparatus as shown in Fig. 5 a tuner amplifier 210 is tuned to separate out a group of radio frequency bands including two bands carrying a desired program intensity modulated out of phase by the same signal or signals, and the output of this amplifier passed to the converter or first detector 212.

The interference intensities of a signal-vacant frequency tuner amplifier 211, the output passing to a converter or first detector 213 and second detector 216, the detected output as before being used in the transformer 217—219 to modulate the energy of the local oscillator 214 and this modulated energy mixed in the converter 212 with the output of the radio frequency amplifier 210 to reduce the carrier frequencies to intermediate frequencies and to demodulate the interference intensities.

The interference having been demodulated the output of the converter 212 passes through the intermediate tuner amplifiers 220, 221 which are broadly tuned to cover the group of frequency bands and the output therefrom is passed in parallel to the two tuner amplifiers 222, 223 which respectively separate out the two normal frequency bands desired which are still in inverted signal intensity relation. These bands then pass through the detectors 224, 225, respectively and are combined in re-inverted phase relation and delivered to the signal output device 230.

The operation of the phase change device shown in Fig. 6 is apparently obvious. Should the phase relation of the output from the detector 260 not be exactly 180 degrees out of phase with the output of the other detector 261, the tap 270 is shifted along the resistance 271 to vary the resistance in the circuit to the condenser and correspondingly varying the resistance to the coil, thereby varying current flow through the condenser and advancing on retarding the phase as the case may be.

Use and actions of the apparatus shown in Fig. 7 is substantially identical with that of the apparatus shown in Fig. 2, except that demodulation of the interference intensities takes place in the radio frequency stage instead of in the intermediate stages.

In using the telephone apparatus shown in Fig. 10, at station 450, the transmitters 452A—B—C—D and E are adjusted to transmit different radio frequencies, here designated A, B, C, D and E respectively, the energy of each transmitter being modulated by its respective microphone 453, or other source of signal. At station 470 the tuner-amplifier receivers 474 A, B, C, D and E are tuned respectively to the same frequencies A, B, C, D and E, and receive, respectively, each the signal transmitted by the transmitter at like frequency in station 450.

In station 470 likewise, the transmitters 472 F, G, H, I and J are adjusted to transmit differing radio frequencies, here designated F, G, H, I and J, these all differing from all the frequencies A, B, C, D and E, and the energy of each being signal modulated by its related microphone. The receivers 454 F, G, H, I and J of station 450 are respectively tuned each to receive signal modulated energy transmitted from a transmitter of corresponding frequency of station 470.

The receivers 457 K and 477 K are tuned respectively to a frequency K not being otherwise used by either station 450 or 470 and not being signal modulated, receive only interference.

Signal-modulated energy sent out from any one of the transmitters as the transmitter 452A, and interference which has entered the circuit is received by its related receiver 474A, and the output of the receiver delivered to its detector 475. Interference likewise enters the receiver 477K, but signal intensities are rejected as their carrier is not of the frequency "K" of this receiver. This interference is detected, in detector 478, and the output delivered to the primary 481 of the modulation transformer, the secondary 482 of which transformer is connected in inverted intensity phase in the output circuit from receiver 474A and demodulates the interference intensities of such output, but having no signal modulated intensities has no demodulating effect on the signal intensities of the output permitting these intensities substantially interference-free to pass to the related receiver set 476.

In using the apparatus shown in Fig. 12; interference received through radio frequency amplifier 570, is impressed on the plate 573 of detector 574, the output being impressed on tube 579 in like manner to that of Fig. 11. Plate voltage variations caused by this interference are impressed on screen grid of tube 554 through condenser 582. Interference and signal entering the radio frequency amplifier 550 is impressed on control grid of tube 554 thereby causing a variation in electronic emission corresponding to their combined energies. The screen grid 558 of this tube having energy impressed on it from other channels in an opposing phase to like interference entering on control grid, will create reduced sensitivity and suppress such interference, and the signal currents being unopposed pass to the secondary of the transformer 576. If two carrier waves are received having been modulated out of phase in intensity by a common signal the energy of such carrier wave as may be received through amplifier 570 will supplement the energy received through amplifier 550 by creating an increased sensitivity of tube 554 at the moment that maximum signal is impressed on its control grid 553.

In using the apparatus shown in Fig. 11; interference received in radio frequency amplifier 525 is impressed on the detector 529 through transformer 526, the detected output creating a voltage across the resistor 531. This energy is impressed on the control grid 534 of tube 535, creating in the plate 536 energy which causes a voltage variation across primary coil of transformer 516, this voltage variation corresponding to the variation in intensity of the interference received by tube 525. The signal and interference received by radio frequency amplifier 510 is impressed on control grid 513 of tube 514, the plate 515, of which is connected through the primary of transformer 516 to the plate 536 of tube 535. The interference received on both channels is of like phase and intensity. Interference impressed at its peak intensity on the detector 529 causes maximum current to flow in said tube, and causing the voltage at plate 536 to be reduced at the same instant that the like high intensity interference is impressed on tube 514, thereby causing minimum voltage drop across primary coil of transformer 516 and creating minimum induced current to the secondary of such transformer, the currents from this point being amplified and detected in usual manner. The signal currents having no like energy on other channel pass unopposed. If two signals are received both being intensity modulated out of phase by a common source of energy the signal received through 525 will supplement that received on 510 by creating maximum voltage drop across primary coil of transformer 516.

In using the device shown in Fig. 13, a carrier wave having desired signal intensities and possible interference, which has been separated out in preceding stages of a first receiver, is impressed on the control grid 611 of a tube in said receiver, which grid is supplied with negative energy from the source of automatic volume control through the leads 632, 631, the resistance 628 and the variable tap 635.

The input of a second and different frequency channel either signal vacant, or having a carrier wave modulated out of phase in intensity by the same signal as said first carrier wave and having in either case the same possible interference as the first channel, and which has been separated out in the preceding stages of the second receiver, is impressed in usual manner on the plate 626 of detector 625, of said second receiver. Signal intensities, if any, reach the plate 626 of said second receiver substantially 180 degrees out of phase with the signal intensities simultaneously reaching the control grid 611 of said first receiver. The low intensities in said detector decrease the negative bias effect of the automatic volume control energy on the control grid of the first receiver at the time that corresponding high intensities are being impressed on this same grid, and conversely the high intensities received in said detector increase the negative bias of said grid at the same time that corresponding low intensities are being impressed thereon, thereby supplementing the signal energies received in the first circuit.

On the other hand interference intensities which enter the two receivers are inherently in phase when they reach the detector plate 626 of the second receiver, and the control grid 611 of the first receiver. High intensities in the detector increase the negative bias effect of the automatic volume control energy on the control grid at the time that the like high intensities are being impressed on said control grid. And low intensities decrease the bias action as like low intensities reach the control grid, thus acting in both cases to cancel such intensities and their effect on the signal intensities of the program. By shifting the position of the variable connection 635 along the resistance 628 the percentage of effect of one receiver on the other is changed through which method equalization of inphase intensity variations is accomplished.

In the uses as set out, the mechanism employed removes, in one of the channels the entering carrier wave frequencies, and impresses the intensities or amplitude variations brought in on such wave, free from carrier frequency, on the carrier wave of the other channel irrespective of the frequency of the latter wave, thus obviating necessity of frequency synchronization.

What I claim is:

1. Apparatus for receiving signals at radio frequency, said apparatus including means for receiving and finally detecting the energy of two differing radio frequency channels and removing the carrier frequencies thereof, and means for impressing the intensity output of the said final detecting means of one said channel, substantially free from any carrier frequency, on the other said channel in advance of the said final detecting means thereof.

2. Apparatus for receiving signals at radio frequency, said apparatus including means for receiving and finally detecting the energy of a plurality of different radio frequency channels and removing the carrier frequencies thereof, and means for superposing the intensity output of the final detecting means of one said channel, substantially free from any carrier frequency, in each other of said channels, prior to said final detection in such channel, or channels.

3. Apparatus for receiving signals at radio frequency, said apparatus including a plurality of means, each means capable of receiving and finally detecting the energy of a different radio frequency channel, said means each including an electron discharge device, and means for impressing the output of the said detecting means of one said channel, substantially free from any carrier frequency, on a said electron discharge device, of each of the others of said channels, prior to their respective final detecting means.

4. Apparatus for receiving signals at radio frequency, said apparatus including a plurality of means, each said means for receiving and finally detecting the energy of a differing radio frequency channel, each said means including an electron discharge device prior to its said final detecting means; and means for impressing the output of one said final detecting means substantially free from any carrier frequency on a grid of said electron discharge device of each of the other said channels.

5. Apparatus for receiving signals at radio frequency, said apparatus including at least two means, each capable of receiving and finally detecting the energy of a radio frequency channel, said means each including an electron discharge device; and means for impressing the output of one of the said final detecting means of one said channel substantially free from any carrier frequency on each other said electron discharge device, said electron discharge device being prior to the final detecting means of its said channel.

6. Apparatus for receiving signals at radio frequency, said apparatus including a plurality of means, each capable of receiving and finally detecting the energy of a different radio frequency channel, said means each including an electron discharge device, and means for impressing the detected output of a said channel substantially free from any carrier frequency on an element of a said electron discharge device of each of the other said channel or channels, said electron discharge devices being respectively located, each in its respective channel prior to the final detecting means thereof.

7. Apparatus for receiving signals at radio frequency, said apparatus including dual means each capable of receiving and finally detecting the energy of a differing radio frequency channel, said means each including an electron discharge device; and means for impressing the output of one said final detecting means on an element of said electron discharge device of the other said channel, said electron discharge device being in advance of the final detecting means of said channel.

8. Apparatus for receiving signals at radio frequency, said apparatus employing two frequency channels, each including a final detector, and means in said apparatus for impressing the output of one said final detector on the other of said channels in advance of the said final detector thereof with the intensities of said output inverted substantially 180 degrees in relation to their entering phase.

9. Apparatus for receiving signals at radio frequency, said apparatus employing two frequency channels, each including a tuner-amplifier and a final detector; a modulation transformer having its secondary in one of said channels in advance of its said final detector, and means for impressing the output intensities of the final detector of the second of said channels on the primary of said transformer with the intensities of said output inverted substantially 180 degrees to their entering phase or phases.

10. Apparatus for receiving signals at radio frequency, said apparatus employing three fre-

quency channels, each including a tuner-amplifier and a final detector, means for impressing the output of the final detector of the third of said channels on the first and second of said channels in advance of the said final detectors of each thereof with the intensities of said output inverted substantially 180 degrees to their entering phase or phases, and means for combining the output of said first and second channel final detectors in relatively inverted phase relation.

11. Apparatus for receiving signals at radio frequency, employing at least two frequency channels, each said channel including receiving means, final detecting means and a modulation transformer having its secondary interposed in circuit between said receiving means and said detecting means; an additional frequency channel including receiving means and final detecting means, and means for impressing the output of said last final detector in parallel on the primaries of said transformers, with the intensities of said output inverted substantially 180 degrees from their entering phase or phases.

12. Apparatus for sending and receiving signals at radio frequency, comprising two related groups of apparatus each group including a plurality of transmitters each operable at a different radio frequency and a like number of receivers each adapted to receive the output of any one of said transmitters, plus an additional modulating device; said receiving apparatus each including a tuner-amplifier and a final detector in circuit, and a modulation transformer having its secondary in said circuit in advance of said final detector; said modulating device including a tuner-amplifier and a final detector; and means for impressing the output of the final detector of said modulating device in parallel on the primaries of said transformers with the intensities of said output inverted substantially 180 degrees to their entering phase or phases.

13. Apparatus for sending and receiving signals at radio frequency comprising two related groups of apparatus, each group including a plurality of transmitters each operable at a different radio frequency each having a microphone; and a like number of receivers each adapted to receive the output of any one of said transmitters, plus an additional modulating device for jointly modulating all of said receivers; said receivers each including a tuner-amplifier, a final detector and a receiving set in circuit and each having a modulation transformer with its secondary in its said circuit in advance of its said final detector; said modulating device including a tuner-amplifier and a final detector; and means for impressing the output of the final detector of said modulating device in parallel on the primaries of said transformers with the intensities of said output inverted substantially 180 degrees to their entering phase or phases.

14. Apparatus for receiving signals at radio frequency, said apparatus employing two frequency channels, each including an amplifying stage and a final detector, and means for impressing the output of the final detector of one said channel on a tube element of said amplifying stage of the other said channel in advance of the final detector thereof.

15. Apparatus for receiving signals at radio frequency, said apparatus including means for receiving and finally detecting the energy of two differing radio frequency channels and removing the carrier frequencies thereof, means for inverting the phase of the intensity output of the said final detecting means of one said channel 180 degrees, and means for impressing the said inverted intensity output substantially free from any carrier frequency, on the other said channel in advance of the said final detecting means thereof.

16. Apparatus for receiving signals at radio frequency, said apparatus including means for receiving and finally detecting the energy of a plurality of different radio frequency channels and removing the carrier frequencies thereof, means for inverting the phase of the intensity output of the said final detecting means of one said channel 180 degrees, and means for superposing the said inverted intensity output, substantially free from any carrier frequency, in each other of said channels, prior to said final detection in such channel or channels.

17. Apparatus for receiving signals at radio frequency, said apparatus employing two substantially independent frequency channels, each including a tuner-amplifier and a final detector; a modulation transformer having its secondary in a first of said channels in advance of its said final detector, and its primary in the second of said channels, after the final detector of said second channel; means for impressing the output intensities of the final detector of said second channel on said transformer primary and means for rendering said second channel inoperative.

18. Apparatus for receiving signals at radio frequency, said apparatus employing two substantially independent frequency channels, each including a tuner-amplifier and a final detector; a modulation transformer having its secondary in a first of said channel in advance of its final detector, and its primary in the second of said channels after the final detector of said second channel; means for impressing the output intensities of the final detector of said second channel on said transformer primary with the intensities of said output inverted substantially 180 degrees from their entering phase, or phases, and means for rendering said second channel inoperative.

19. Apparatus for receiving signals at radio frequency, said apparatus employing two frequency channels, each including an amplifying stage and a final detector, means for inverting the phase of the intensity output of one said final detector substantially 180 degrees from its entering phase, and means for impressing said inverted intensity output on a tube element of said amplifying stage of the other said channel in advance of the final detector thereof.

20. Apparatus for receiving signals at radio frequency, said apparatus employing two frequency channels, each including a tuner-amplifier and a final detector; a modulation transformer having its secondary in one of said channels in advance of its said final detector, and means for impressing the output intensities of the final detector of the second of said channels on the primary of said transformer.

21. Apparatus for receiving signals at radio frequency, employing a plurality of frequency channels, each said channel including receiving means, final detecting means and a modulation transformer having its secondary interposed in circuit between said receiving means and said detecting means; an additional frequency channel including receiving means and final detecting means, and means for impress-

ing the output of said last final detector in parallel on the primaries of said transformers.

22. Apparatus for sending and receiving signals at radio frequency, comprising two related groups of apparatus, each group including a plurality of transmitters each operable at a different radio frequency, and a like number of receivers each adapted to receive the output of any one of said transmitters, plus an additional modulating device; said receiving apparatus each including a tuner-amplifier and a final detector in circuit, and a modulation transformer having its secondary in said circuit in advance of said final detector; said modulating device including a tuner-amplifier and a final detector; and means for impressing the output of the final detector of said modulating device in parallel on the primaries of said transformers.

23. Apparatus for sending and receiving signals at radio frequency, comprising two related groups of apparatus, each group including a plurality of transmitters each operable at a different radio frequency, each having a microphone; and a like number of receivers each adapted to receive the output of any one of said transmitters, plus an additional modulating device for jointly modulating all of said receivers; said receivers each including a tuner-amplifier, a final detector and a receiving set in circuit, and each having a modulation transformer with its secondary in its said circuit in advance of its said final detector; said modulating device including a tuner-amplifier and a final detector; and means for impressing the output of the final detector of said modulating device in parallel on the primaries of said transformers.

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